Schneider Electric™
Sustainability Research Institute

Digital Series

# IT and Electricity

## A bottom-up forecast of the IT sector electricity consumption

Vincent Petit

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Life Is On | Schneider Electric

# Introducing our Sustainability Research Institute

Progress on energy and sustainability is at an all-time high. How will that momentum fare in a new decade – and under radical new circumstances?

It is our responsibility, as large organizations, to make a positive impact by reducing energy consumption and $CO_2$ emissions, contributing to societal progress, while being profitable.

At Schneider we have ambitious targets with our 2021–2025 Schneider Sustainability Impact (SSI), in line with the United Nations Sustainable Development Goals; our technologies reconcile growth, access to energy for all, and a carbon-free future for our planet. Our own climate commitments aim to minimize carbon emissions for our customers and our own company. For Schneider, this means the neutrality of our business ecosystem by 2025, net-zero carbon from our operations by 2030, and net-zero carbon of our end-to-end supply chain by 2050.

With pioneering technology and end-to-end solutions for sustainability, we've been building momentum.

The Schneider Electric Sustainability Research Institute examines the issues at hand and considers how the business community can and should act: we seek to make sense of current trends and what must happen to maintain momentum, and preview the changes that we believe are yet to come.

In this white paper, we take a look at the key risks associated with the rise of information technology (IT) in terms of electricity consumption, offering a refined forecast for IT electricity consumption up to 2030. Our conclusion: while we know that the digital economy will require significantly more energy in the future – and some observers voice considerable concerns over this – we find that climate impact is likely to remain limited by progress in IT technology, as well as the rapid adoption of clean power sources by the sector.

To achieve sustainability goals set out by hundreds of global organizations, bold steps are required to reduce emissions and operate more sustainably.

Join us in this series where we explore compelling predictions and conclusions in the areas of energy management, digital innovation, climate action, goalsetting and confidence, and fresh financing mechanisms.

It is time to embrace sustainability as a business imperative, and to capture the momentum now, for the future.

**Oliver Blum**
Chief Strategy and Sustainability Officer, Schneider Electric

**Vincent Petit**
SVP Strategy Prospective and External Affairs, Schneider Electric

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# Digital transformation during a pandemic

As the Internet of Things (IoT) and other enhanced digital applications become a reality, internet traffic is rising rapidly. The COVID-19 pandemic has also accelerated this trend.

Video conferencing provider Zoom, for example, reported that its user base increased from 10 million in December 2019 to 200 million in March 2020, as millions of people moved their work and schooling online.

Some 1.2 billion students worldwide were kept away from their physical study spaces, and millions of remote workers stayed connected via platforms and applications like Slack, Trello, Jira and Zoom.

Since the outbreak, consumption of in-home digital media and video streaming by worldwide internet users increased significantly.

- 51 percent of the world's population watched more shows/films on streaming services.
- 45 percent of the world's population spent longer on messaging services (i.e., Facebook and WhatsApp).
- 44 percent of the world's population is spending longer on social media (i.e., Facebook, Instagram or Twitter).

When the world locked down, the world also logged on, and internet traffic soared.

A recent *Workforce of the Future survey*[1] confirmed that out of the 10,000 people polled, 87 percent wish to continue having the flexibility to choose to work from home or in the office once COVID-19 restrictions ease. Increasingly remote work, relying on digital applications will be necessary for businesses to stay connected and productive.

Meanwhile, how the IT sector feeds the world's insatiable digital appetite could have broad ramifications for society and possibly hamper efforts to combat climate change. This has been recently emphasized by think-tanks and industry observers, who stress the possible environmental impact of the sector's ever-increasing power consumption.

However, it would be misleading to simply assume that IT and digital activity will inevitably result in a massive and deeply problematic increase in $CO_2$ emissions.

After all, future innovation will also deliver better efficiency across the broader connectivity landscape and will help mitigate just how much electricity and emissions ultimately result from an increased appetite for digital technologies.

So, as we look to the future, we need to ask ourselves: Will the rapid rise in data center services be as disruptive in terms of electricity consumption as for instance the growth of electric vehicles? How far will the exponential increase in online activity impact worldwide electricity use and carbon emissions? Or, on the contrary, can efforts to integrate systemic energy efficiency with digitalization boost decarbonization?

[1] Cisco & Dimensional Research (2020), The Rise of the Hybrid Workplace, A Global Survey of Executives, Employee Experience Experts, and Knowledge Workers



# Digitalization is boosting electricity use

Digital technologies are widely used across all sectors. In the world of real estate, more residential and commercial buildings are fitted with smart appliances and intelligent energy management systems than ever before. In industry, automation, advanced robotics and 3D printing are increasingly common. In transportation, the interaction between automated, connected, electric and shared (ACES) mobility is beginning to emerge.

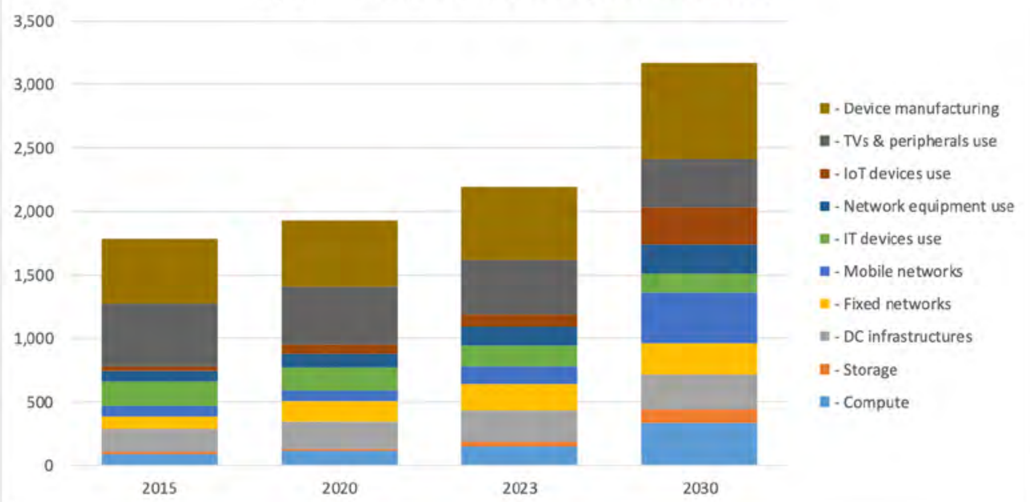
**To understand how these digitized and smart applications will be powered in the future, Schneider Electric has developed research and modelling to forecast until 2030 the electricity required to maintain the IT-sector's development. This review puts to rest many of the worst-case scenario claims which predict that IT-related electricity use will double every five years.**

Schneider Electric's research details IT-sector electricity consumption forecasts for the next decade, covering data center servers and storage capacity, fixed and mobile internet demand, device-connectivity and manufacturing, while considering evolutions in both demand and efficiency.

Despite a thorough review of services demand evolutions, this research effort does not however go so far as to consider the potential impact of still emerging digital applications, such as for instance autonomous vehicles, blockchain developments, or further technology innovations on new forms of artificial intelligence (AI), or computing. This conservative approach to future IT demand forecasting appears to be best suited to frame the debate around energy and climate implications of the sector's development, considering the prevalent uncertainty on future technology developments. It is also consistent with other external publications. This however calls for further research to be developed in the future as these new innovations materialize.

**Schneider Electric estimates that IT sector electricity demand will grow by 50 percent by 2030, reaching 3,200TWh, equivalent to 5 percent Compound Annual Growth Rate (CAGR) over the next decade.**

Figure 1 - Evolution of IT energy demand (TWh)

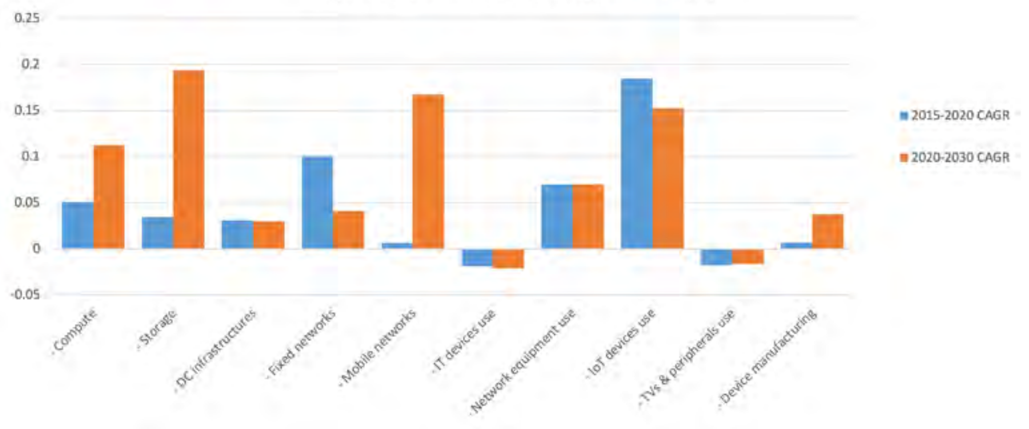


From 2015-2020, major efficiency gains have been delivered through all segments, limiting annual growth to 2 percent CAGR. This has been notably visible in data centers (compute, storage, PUE, etc.) and mobile networks (switch to 4G). Fixed networks (the bulk of IP traffic) have shown slightly less efficiency gains, however.

75 percent of the growth to 2030 is expected to come from data centers and networks, particularly from the high increase of compute instances (and data storage for big data applications and AI) and mobile communications (including the switch to 5G). Devices manufacturing and use, which represented around 70 percent of total energy demand of the sector in 2015, sees its share falling to around 50[2] percent by 2030, with a minor contribution to overall demand growth. In fact, the relative decrease of traditional devices energy demand is compensated by the penetration of IoT devices across all sectors of activity.

The essence of the growth to 2030 will thus come from accelerated IP traffic, particularly through mobile networks, with massive data generation from IoT devices, leading to a sharp increase in compute and storage requirements in data centers to make use of all this data.

Figure 2 - Evolution of IT energy demand (%)




[2] There is still uncertainty on the exact energy footprint of 5G, notably the exact energy demand during idle time and the corresponding impact on total power requirements. We have taken here assumptions based on best available data.

This forecast takes stock of recently observed efficiency gains and project them further to 2030, taking key assumptions regarding possible IT- and power-related efficiencies from data centers, mobile networks development, the share of fixed and mobile access networks per application, as well as additional efficiencies gained during device manufacturing. Sensitivity analyses suggest that IT sector electricity demand could reach up to 4,700 TWh by 2030 (compared to 3,200 TWh in current forecast), if zero additional efficiencies were factored in, a highly unlikely prospect however considering double-digit efficiency improvements seen over the past decade.

It is challengeable to make a direct comparison with other similar forecasts due to differences in terms of the actual scope covered. To date, there is indeed no standardized measurement framework. This is particularly true when forecasting the use and manufacturing of IT devices. For instance, Schneider Electric's research measures the electricity required to manufacture a wide range of IT devices, from IoT-enabled units featuring electronics and sensors and connectivity applications, such as smart TVs and other peripherals. The perimeter of review varies significantly across forecasts as explained by Andrae[3] (2020) in his most recent analysis.

Despite such difficulties, Schneider Electric's projections have been rigorously reviewed against similar research from a global community of expert research bodies. When compared to peers, Schneider Electric's forecasts are remarkably close to the most recent analyses from Andrae[4], an update from his foundational review "On Global Electricity Usage of Communication Technology: Trends to 2030" published in 2015[5]. These 2020 revised analyses from Andrae forecast IT demand between 2,200TWh and 3,200TWh by 2030, close to the 2015 study's best-case scenario. In 2015, mid-case and worst-case scenarios, at 8,200TWh and 30,700TWh respectively, were also published.

Schneider Electric's forecast has also been reviewed against the 2020 analysis from the International Telecommunication Union[6], The report forecasts a growth from around 1,000TWh in 2015 to 1,200TWh by 2030, both a much lower baseline and growth to 2030, compared to Schneider Electric's analysis.

Due to these significant differences in baseline, a better way to compare these forecasts is also to look at average rates of growth (CAGR). The 2020 latest forecast from Andrae stands at around 5 percent CAGR, a trend highly consistent with Schneider Electric's own modelling. The forecast from the International Telecommunication Union is much more conservative, estimating an increase of 1.5 percent CAGR, similar to currently observed rates of growth.

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[3] Anders Andrae (2020), Hypotheses for primary energy use, electricity use and $CO_2$ emissions of global computing and its shares of the total between 2020 and 2030.

[4] Overall forecast levels match well despite notable differences in data center , device use and manufacturing demand.
Anders Andrae (2020), Hypotheses for primary energy use, electricity use and $CO_2$ emissions of global computing and its shares of the total between 2020 and 2030.
Anders Andrae (2020), New perspectives on internet electricity use in 2030.

[5] Anders Andrae and Tomas Edler (2015), On Global Electricity Usage of Communication Technology: Trends to 2030.

[6] International Telecommunication Union (2020), Greenhouse gas emissions trajectories for the information and communication technology sector compatible with the UNFCCC Paris Agreement.



# Methodology – Demand drivers in the digital landscape

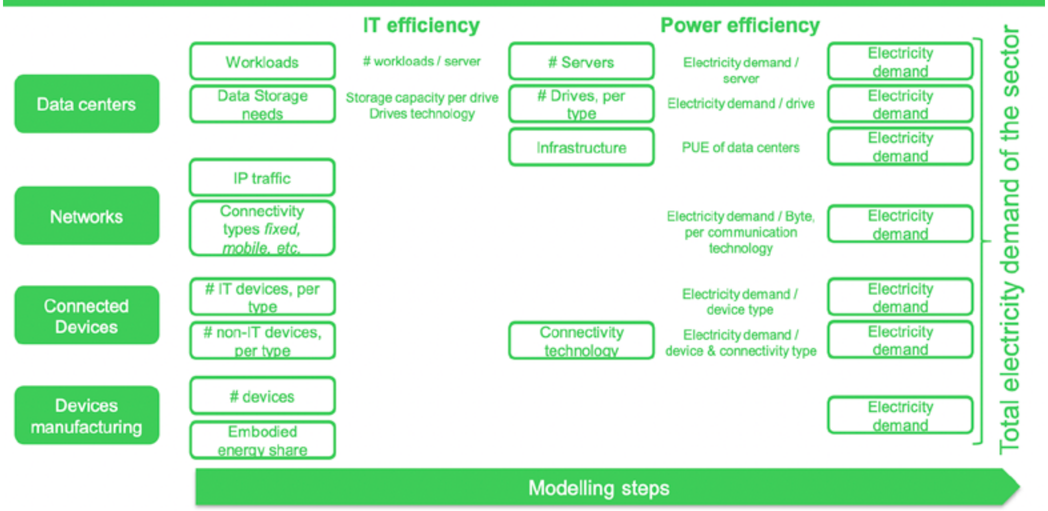
In 2020, the overall IT sector represents between 5 and 15 percent of global electricity consumption, depending on the external forecast available. This is due – again – to scope differences and modelling specificities.

Schneider Electric's own model estimates current global IT-related electricity demand to account for 1,900TWh, or 8 percent of total electricity demand. This is globally consistent with the research from Andrae in 2020[7] at 1,700TWh and that from the International Energy Agency 2017 report forecast[8], at 1,400TWh, when accounting for scope differences.

Schneider Electric's model uses a bottom up approach, based on the following drivers for electricity demand growth from digitalization.

- Firstly, it estimates IT service demand growth until 2030, including the number of compute instances, data storage requirements, data center infrastructure – both edge and cloud-based, IP traffic demand – across both fixed and mobile networks, as well as demand related to IT devices in operation and for manufacturing.
- Additional factors relating to IT efficiencies, from virtualization, storage efficiency and network improvements, and power efficiencies from both embodied energy and energy use efficiency are subsequently applied to the model.

**Figure 3 - Bottom-up analysis of IT electricity demand and evolutions**




More details on the paper's methodology and the results of Schneider Electric's modelling can be found in the paper's annex. The following sections outline key findings of the research.

For the reader's convenience, sections are sub-divided to show main results per sector of activity.

[7] Anders Andrae (2020), Hypotheses for primary energy use, electricity use and $CO_2$ emissions of global computing and its shares of the total between 2020 and 2030

[8] © OECD/IEA (2017), in fact - Digitalization and Energy



## Section 1 – More data: The impact of digitalization on computing and data storage

**Digitalization is primarily about harnessing, storing and computing data. The rise of data use and services across all sectors of activity will be a key engine of growth for the IT sector, and a key driver of increased electricity demand to 2030.**

### Workloads and servers

Compute instances will continue to increase dramatically due to demand from digital technologies. Artificial intelligence (AI) is becoming more prevalent for both consumers and businesses: machine-to-machine (M2M) applications are increasing, and more people, processes, data, and things are connecting to the internet, and to each other.

Cisco, the US networking technology provider, periodically tracks and publishes global workload forecasts in its *Annual Global Cloud Index*[9]. It reports a 21 percent CAGR over the period 2016-2021.

At the same time, the utilization rate of servers continues to increase, notably thanks to server virtualization. Cisco estimated a 6 percent CAGR of the number of servers in operation over the period to 2021.

However, industry analysts agree that software-driven IT efficiencies will not continue to deliver the same levels of optimization as achieved over recent years, notably due to the rise of edge computing, where more servers are not fully virtualized.

Building on Cisco estimates, Schneider Electric's research forecasts that the number of servers will grow at 13 percent CAGR to 2030. This increase is driven by the rise in compute instances from social networking and video streaming services (at a similar rate than previous), as well as IoT applications, but also intensified by limitations in terms of IT efficiency[10].

### Data storage

If digitalization is defined as computing data, it is also important to consider how that data is stored for further use. And as the world generates more data, at an average 30 percent CAGR over the last few years, according to the *United States Data Center Energy Usage Report*[11], this trend is set to continue. The industry analyst IDC predicts[12] that the "Global Datasphere" will grow from 33 Zettabytes (ZB) in 2018 to 175 ZB by 2025, despite only a fraction of that datasphere being effectively stored.

At the same time, storage drive technologies keep evolving. Gradually replacing hard drives (HDD) with more efficient solid-state drives (SSD) will also enable further IT efficiencies. Considering both evolving storage drive capabilities and the mix of drives in operation[13], the number of drives is still expected to grow at 22 percent CAGR until 2030.

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[9] Shehabi et al. (2016). United States Data Center Energy Usage Report; Arman Shehabi, Sarah Smith, Dale Sartor, Richard Brown, Magnus Herrlin

[10] IDC/Reinsel, Gantz & Rydning (November 2018), The Digitization of the World From Edge to Core White Paper

[11] Shehabi et al. (2016). United States Data Center Energy Usage Report; Arman Shehabi, Sarah Smith, Dale Sartor, Richard Brown, Magnus Herrlin

[12] IDC & Seagate (2018), The Digitization of the World From Edge to Core

[13] We have assumed conservatively a halving of efficiency gains compared to previous period, and a rise of SSD penetration up to 51 percent of total by 2030.

## Electricity demand

Despite progress over the last decade, sustained efficiency impacts will hence be more difficult to achieve, as much of the progress of recent years has come from increased virtualization and the move to cloud-based computing. Historical IT efficiencies are starting to reach maximum capacity, notably due to cloud-computing server virtualization, increased computing at the edge (with limited virtualization), alongside forecasts of significant growth in storage required for big data and AI applications. Any additional power efficiencies from hardware will therefore be critical to limit electricity demand growth, however such hardware-related gains are thought to deliver slower results in comparison to those from software-driven IT efficiencies.

The power requirements needed to handle increases in server workloads have benefitted from approximately 1-2 percent improvements in energy intensity per year, as observed in recent research published in the U*nited States Data Center Energy Usage Report*[14]. Schneider Electric projects this trend to continue until 2030. These forecasts have also been confirmed through a set of benchmarks[15] of over 300 different servers which are published quarterly by the Standard Performance Evaluation Corporation's power database. Schneider Electric's model estimates as a result electricity requirements needed to power the world's installed servers are set to increase at 12 percent CAGR until 2030, or 2.5 times faster than in the previous period.

In parallel, power savings are expected from increased storage-drive efficiency and density gained with the adoption of solid-state drive (SSD) technology. While remaining moderate, a 1 percent improvement in energy intensity per year is forecast across all drive types. Together these efficiency gains will result in electricity requirements growing at 21 percent per year, or 6 times faster than in the previous period.

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[14] Shehabi et al. (2016), United States Data Center Energy Usage Report; Arman Shehabi, Sarah Smith, Dale Sartor, Richard Brown, Magnus Herrlin

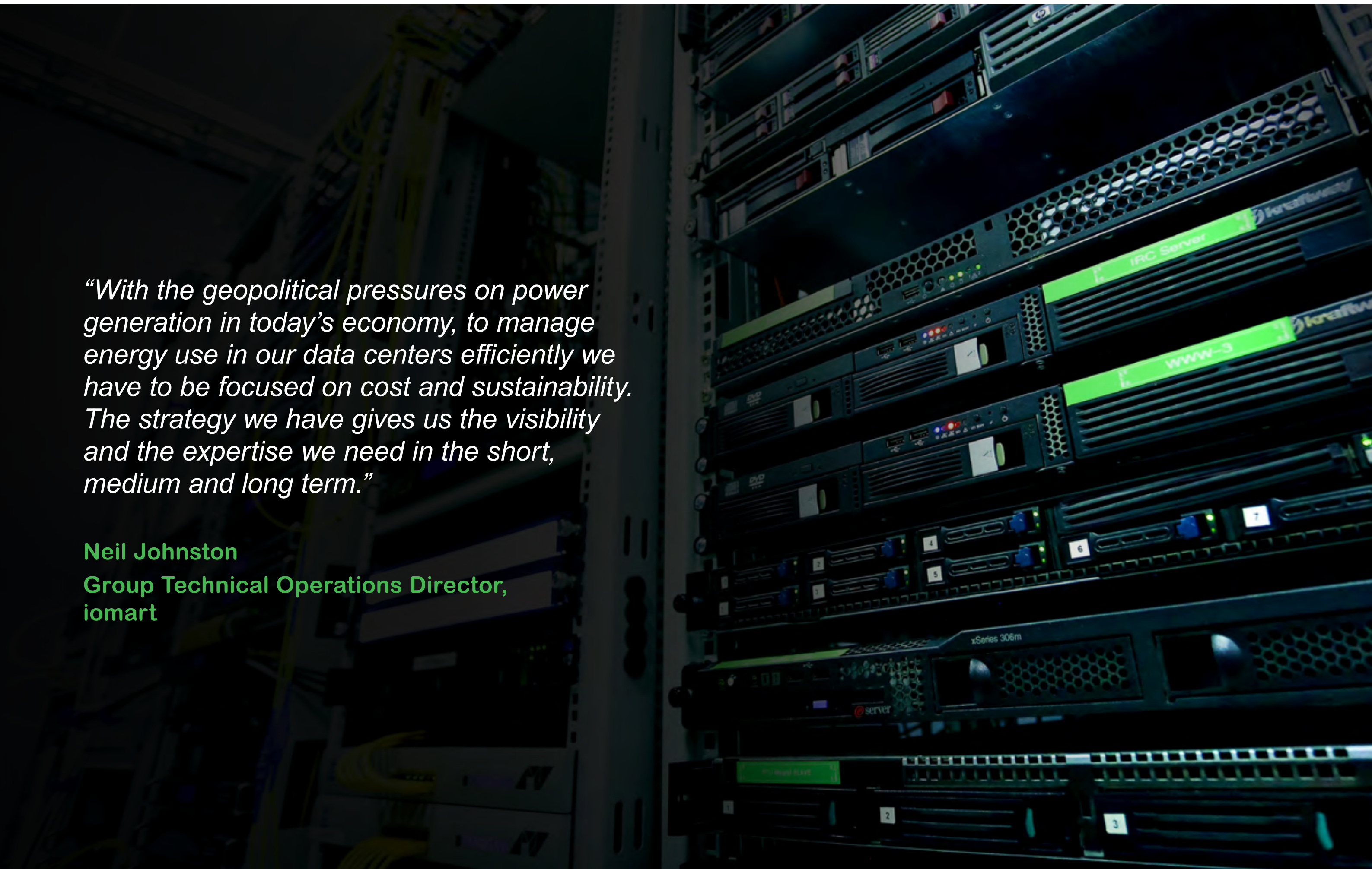
[15] SPEC (2008), Standard Performance Evaluation Corporation. SPECPower.

# Case study: iomart

As one of Europe's leading cloud-computing companies and accredited as a Tier1 partner by all major cloud vendors, iomart started its journey to sustainable growth by reducing energy consumption across its data centers. The organization has applied the same guiding principles that deliver value for its customers (including Microsoft, VMware, EMC and AWS) to its own organization. This winning formula of improved efficiency, reduced costs and improved flexibility is what makes iomart a responsible data center provider.

By taking an integrated approach to energy and sustainability, iomart reduced energy costs by 13 percent and found €1.5M in savings, to meet energy compliance standards. Sharing energy procurement data was key to supporting reporting needs, resulting in ISO50001 accreditation by monitoring both energy consumption and power usage effectiveness, and to identifying capital cost allowance and Carbon Reduction Commitment Energy Efficiency Scheme rebates.

iomart continues to create new opportunities for more savings from metering using Resource Advisor software to automate processes and enable data visualization and management.



*"With the geopolitical pressures on power generation in today's economy, to manage energy use in our data centers efficiently we have to be focused on cost and sustainability. The strategy we have gives us the visibility and the expertise we need in the short, medium and long term."*

**Neil Johnston**
**Group Technical Operations Director, iomart**



# Section 2 – The evolving landscape of data centers: The shift to Cloud, the rise of the Edge

**The growth of cloud computing has resulted in significantly larger data centers with lower power usage effectiveness (PUE), compared to traditional enterprise data centers. Yet, the development of edge computing is likely to limit further aggregated PUE improvements.**

By combining the annual forecasted PUE improvements, ranging around 2 percent CAGR until 2030 (similar to recent annual improvements), and the actual and projected share of both edge and cloud data centers[16], Schneider Electric's model provides an estimate of overall electricity demand for data center infrastructure.

If the shift to cloud computing has significantly helped optimize PUE in recent years[17] – with average levels often below 1.2, the rise of edge computing in the coming decade will, in part, offset this sustained improvement, as today edge data center PUE is often closer to 2.

Combining these continuous efficiency improvements and the increasing share of edge data centers, yields steady growth in data center infrastructure electricity demand at 3 percent CAGR to 2030.

[16] We have assumed a growth of edge capacity at nearly twice the rate of data centers, Schneider Electric research

[17] A trend that is set to continue. Masanet et al. (2020), Recalibrating global data center energy-use estimates

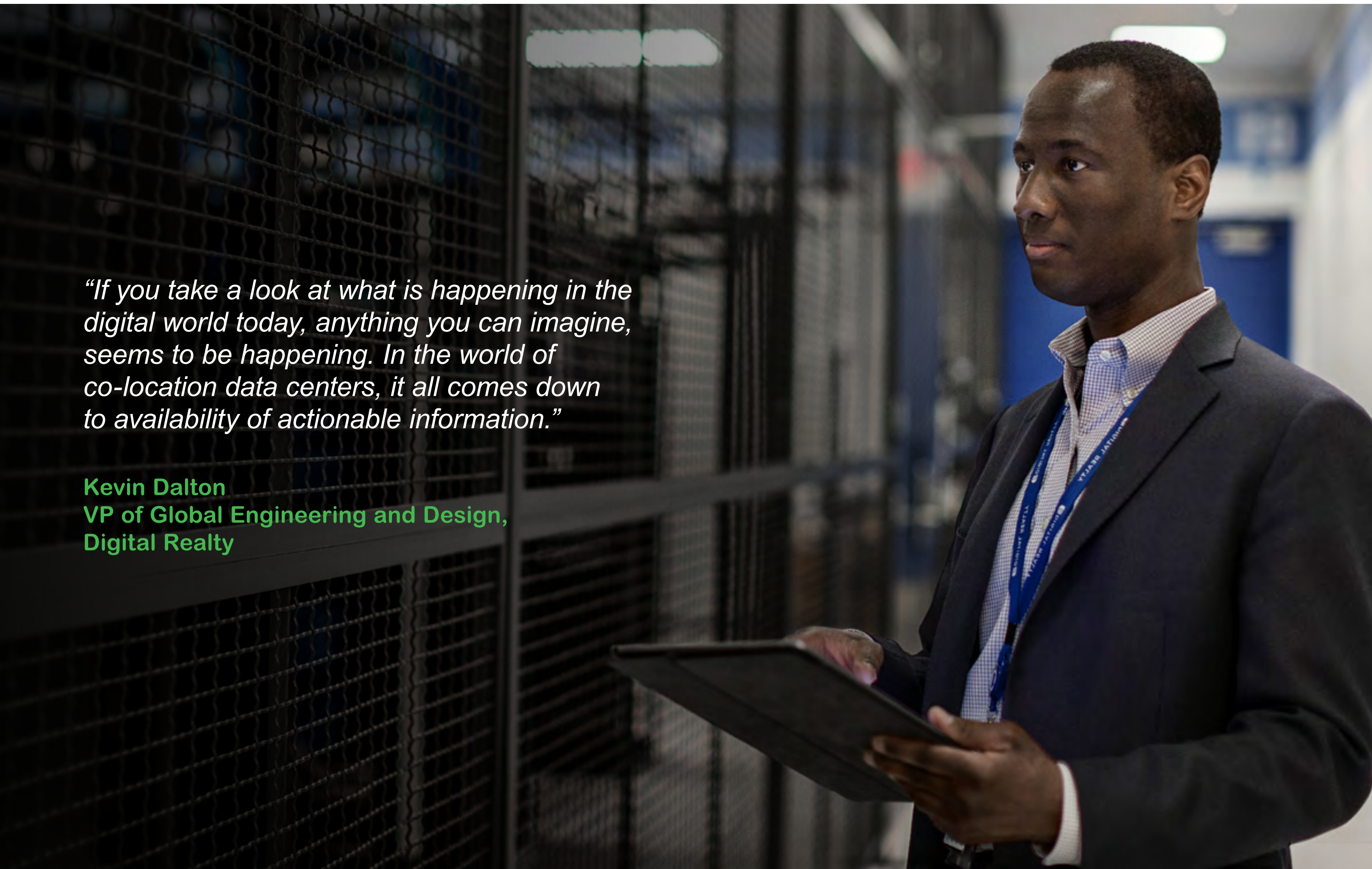
# Case study: Digital Realty

Data centers are “the factories of the digital economy”. The growth of cloud computing has led to significantly larger data center spaces that are delivering world-class efficiency, both in terms of server utilization and infrastructure PUE. In fact, trends in hyperscale data spaces as well as increased popularity in very large co-location or cloud facilities, keep improving PUE ratios.

As a global data center partner, Digital Realty is trusted with the mission-critical architectures of some of the top companies in social media, financial services, and health care. Their industry-leading record assures customers that they will never go dark and can count on the security, reliability, and agility required to support their high-performance networks.

Its 170 data centers serve more than 2,300 customers in 33 metro markets, across four continents. Increasing customer requests for visibility needed to be met simply and consistently.

Accurate information on critical assets and the operating environment is invaluable to Digital Realty’s customers, and with EcoStruxure™, not only do they get that information, it’s available from virtually anywhere. EcoStruxure™ also collects and aggregates operating data for analysis and reporting, providing crucial operating information to customers, which keeps Digital Realty at the head of the pack in the constantly evolving colocation industry.



*“If you take a look at what is happening in the digital world today, anything you can imagine, seems to be happening. In the world of co-location data centers, it all comes down to availability of actionable information.”*

**Kevin Dalton**
**VP of Global Engineering and Design,**
**Digital Realty**



## Section 3 – More communication with next generation data transmission technologies

**Internet traffic is one of the key drivers of electricity demand growth to 2030. The bulk of internet traffic today relies on fixed networks, but mobile access is projected to gain significant shares in the coming decade, a continuation of the trend observed in the last years. At the same time, new mobile access technologies emerge. They are both more powerful (hence foster adoption, and new uses), and more energy efficient.**

### IP traffic

Global internet traffic is the biggest indication of demand growth for IT services; in 2020 data traffic already accounts for around 20 percent of the IT sector's annual electricity consumption (covering both fixed and mobile networks and associated networking equipment).

Cisco[18] [19] estimates that internet traffic will grow 26 percent CAGR to 2023. Internet traffic is currently unevenly distributed across various fixed (wired, WiFi) and mobile (2G-5G) access systems, with a significant increase expected in mobile networks. Mobile traffic is indeed forecast to grow at 46 percent CAGR until 2023, stemming primarily from the 260 billion mobile applications estimated to be downloaded by 2021. Increases in video applications are also expected to continue to rise and have been estimated to represent 82 percent of global internet traffic by 2023. Schneider Electric’s modelling assumes these growth projections are set to continue until 2030.

Global mobile connectivity coverage and usage vary widely across the globe. By 2023 basic 2G networks will nearly disappear, and 5G networks will progressively substitute their 3G and 4G equivalents. With the first true 5G networks already live, Schneider Electric’s model estimates that 5G could represent 70 percent of total mobile traffic by 2030[20].

### Electricity demand

Each of these access systems has shown efficiency improvements over recent years. For fixed access at least, this can be expected to continue. Even greater energy-intensity improvements, however, come from changes in mobile access systems. The International Energy Agency[21] reports that 4G is already five times more energy efficient than 3G, and 5G is expected to be between 10 and 20 times more energy efficient than 4G by 2030.

On-premise networking equipment, such as broadband modems, were also included in the forecast. Electricity demand of these internet-enabling devices is projected to continue to grow at a constant 7 percent CAGR until 2030[22].

By combining internet traffic growth forecasts, the evolution of telecommunication networks, notably the growing share of mobile traffic, and predicted energy efficiency gains per technology type, total electricity consumption related to telecommunication networks is predicted to grow at 10 percent CAGR to 2030, or 3 times faster than in the previous period.

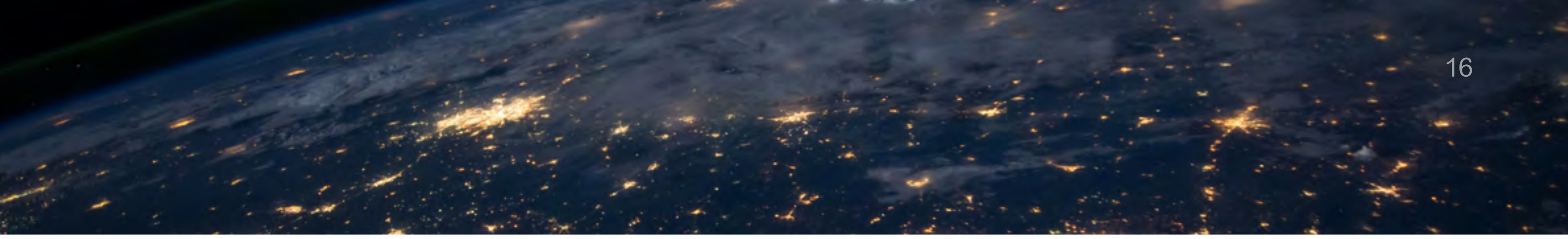
[18] Cisco (2018), Cisco Visual Networking Index (VNI) Complete Forecast Update, 2017–2022

[19] Cisco (2019), Cisco Visual Networking Index (VNI) Complete Forecast Update

[20] Other forecasts have been more conservative (International Telecommunication Union, 2020). We assume here rapid uptake of the technology due to its inherent advantages.

[21] © OECD/IEA (2020), Data Centres and Data Transmission Networks

[22] Lanzisera et al. (2010), Data Network Equipment Energy Use and Savings Potential in Buildings





# Section 4 – Devices and sensors expanding the connectivity landscape

**IT sector electricity demand is also affected by the future development of devices used to interact with IT systems. Electricity demand varies across the different types of devices, with desktop PCs and laptops typically requiring significantly more power than tablets or smartphones. With the rise of the next stage of digitalization – the Internet of Things (IoT), the connectivity requirements and associated electricity demand are also set to increase significantly.**

## IT devices

An estimation of the projected number of IT devices has been modelled, based on various research studies, from Andrae & Edler, Cisco, the International Energy Agency, Koomey and Naffziger, and the Fraunhofer Institute for Systems and Innovation Research[23].

For instance, the number of PCs (both desktops and laptops) in operation will gradually decrease to 1.2 billion (-2 percent CAGR) by 2023. At the same time, the number of tablets and smart phones will continue to grow, with an estimated 0.9 billion tablets (4 percent CAGR) and 6.7 billion smartphones (7 percent CAGR) in operation by 2023.

Building on those forecasts, Schneider Electric's analysis estimates that the total number of IT devices will increase at 5 percent CAGR until 2030. Smartphones will also gradually replace the 2.3 billion cell phones that were in use in 2018.

## Internet of Things (IoT)

As Cisco[24] estimates that M2M connections will nearly triple from 5.9 billion in 2018 to over 14.5 billion by 2023 (20 percent CAGR), the assumption is that this trend will continue at a similar pace.

Connectivity requirements will, however, depend on the specific applications in use. 4G and 5G connectivity will compete with other connectivity solutions, such as low-power wide-area networks (LPWAN) or WiFi, particularly across workplace, healthcare, home and automotive applications. Schneider Electric model estimates that 4G and 5G connectivity will apply to 28 percent of total IoT devices by 2030, the rest being connected thru other solutions.

## Electricity demand

Desktop PCs consume more power due to their processing, programming and data storage capabilities, in contrast to laptops which are more efficient. Schneider Electric's modelling estimates that energy intensity will progressively decline, at -2 percent CAGR for laptops beyond 2021. However, little change in device efficiency is expected for tablets and smartphones by 2030. Any improvements in energy efficiency are likely to be offset by more complex processing requirements, as these devices progressively take over from PCs to operate the next generation of applications.

[23] Anders Andrae and Tomas Edler (2015), On Global Electricity Usage of Communication Technology: Trends to 2030
© OECD/IEA, Electronic Devices & Networks Annex (2019, 2021), Total Energy Model for Connected Devices   Cisco (2018), Cisco Visual Networking Index (2017-2022)
Cisco (2019), Cisco Visual Networking Index (VNI) Complete Forecast Update
Cisco (2020), Cisco Annual Internet Report (2018–2023)
Fraunhofer (2017), Energy Consumption of Consumer Electronics in US Homes 2017.
Koomey and Naffziger (2015), Moore's law might be slowing down, but not energy efficiency

[24] Cisco (2017), Cisco Annual Internet Report (2018–2023)

For IoT applications, Schneider Electric's analysis focuses solely on the electricity demand associated with additional connectivity, rather than fully integrating the energy requirements of such appliances. It is worth noting that most of these connected devices run idle 50 percent of the time – a critical element to accurately forecasting the electricity effectively consumed from IoT connectivity[25].

In addition, connected TVs and TV peripherals have been included in Schneider Electric's forecasts. While the volume of these devices in operation is expected to remain stable[26], energy efficiency improvements from new models are expected to result in an average 3 percent CAGR improvement until 2030, as older models get progressively replaced.

By combining all device types and IoT connectivity requirements, the related electricity demand will grow at 3 percent CAGR, a much faster growth rate than observed in the previous period. This growth is mainly due to the significant acceleration of IoT-associated demand, with efficiency gains across other devices cutting overall electricity demand growth.

25 Mahmoud et al. (2016), A Study of Efficient Power Consumption Wireless Communication Techniques/Modules for Internet of Things (IoT) Applications

26 Reference (2020). How Many TVs Are There in the World?
Anders Andrae and Tomas Edler (2015), On Global Electricity Usage of Communication Technology: Trends to 2030



# Section 5 – Energy outlook for device manufacturing

**The manufacturing of new IT devices, such as phablets, with large displays, smartphones which will replace old-generation mobile phones and broadband modems, will account for a sizeable share of growth in electricity consumption.**

Based on estimates on the worldwide production of consumer electronic devices from multiple sources[27], Schneider Electric has modelled the energy consumption per device manufactured to reveal its impact on electricity demand.

This analysis incorporates the total number of devices manufactured and the actual embodied energy per device type. By leveraging research by Andrae & Corcoran on lifecycle energy analysis[28], Schneider Electric's model considers additional potential efficiencies achieved in manufacturing. Current estimates already account for annual savings of around 3 percent CAGR across most device manufacturing processes.

Schneider Electric extrapolates on this analysis to an estimated 4 percent CAGR in electricity demand until 2030, despite significant uncertainties associated to variations in the estimated life spans of different consumer electronic devices. Some uncertainty also remains in relation to the difference in scope covered between different studies. For instance, Andrae's latest forecast[29] (which predicts a decline in electricity demand from manufacturing) only focuses on consumer electronic devices. Overall, the Schneider Electric forecast estimates a 4 times acceleration compared to the previous period.

[27] Anders Andrae and Tomas Edler (2015), On Global Electricity Usage of Communication Technology: Trends to 2030
Broadband TV (2018), World Cup pushes global TV shipments to 221m in 2018
Gagliordi N. (2018), Sales of 2-in-1 devices to carry a sinking PC market in 2018: IDC. ZDNet.
Gartner (2019), Gartner Says Global Device Shipments Will Be Flat in 2019
IDC (2019), IDC's Worldwide Quarterly Mobile Phone Tracker. Available in Business Wire.
© OECD/IEA, Electronic Devices & Networks Annex (2019), Total Energy Model for Connected Devices
Statista (2020), Computing device shipments forecast worldwide from 2013 to 2020, by segment type ; Number of smartphones sold to end users worldwide from 2007 to 2021

[28] Andrae & Corcoran (2013), Emerging Trends in Electricity Consumption for Consumer ICT

[29] Anders Andrae (2020), Hypotheses for Primary Energy Use Electricity Use and $CO_2$ Emissions of Global Computing and its Shares of the Total between 2020 and 2030

# A perspective of digitalization on electricity demand and carbon emissions

## Growth in electricity demand, but limited impact on carbon emissions from the IT sector

Schneider Electric's estimates reveal a significant rise in IT-sector related electricity demand, increasing by 50 percent from around 1,900TWh in 2020 to 3,200TWh in 2030. Yet this must be placed in context and should not be presented alarmingly as "out of control". In fact, this forecast is similar to the International Energy Agency's[30] 2030 projections for additional electricity demand from air conditioning, at around +1,200TWh, and twice that of Bloomberg New Energy Finance[31] (BloombergNEF) for electric vehicles, at around +500TWh.

The IT sector would therefore still only represent 10 percent of total electricity demand by 2030. This is a slight increase from the sector's current share which is estimated today at 8 percent.

As IT energy demand is essentially electricity-based, any impact of its growth on carbon emissions is primarily related to electricity generation carbon intensity. BloombergNEF's New Energy Outlook (2019) research estimated that the $CO_2$ intensity (reported in $gCO_2$/kWh of electricity) of the global power generation system will decrease by around 25 percent by 2030. Therefore, according to the Schneider Electric model, the resulting emissions from IT sector electricity demand would increase by around 26 percent. In absolute terms, this means a growth from around 0.95$GtCO_2$/y in 2020 to 1.2$GtCO_2$/y in 2030, or an increase of nearly 0.3$GtCO_2$/y This corresponds to an increase of 0.5pt in total energy-related $CO_2$ emissions, at 3.4% of total by 2030.

This projection is run from global averages, while the carbon intensity of electricity generation obviously varies significantly from one region to another. The lack of data available on where IT services are effectively consumed however prevents from running a more refined analysis. This best estimate of carbon emissions impact (in share of total emissions) is in line with the latest forecast from Andrae[32].

This additional environmental impact of the IT sector is however likely to be much lower in reality, as most major IT players operating data center or network infrastructure have indeed made public commitments to rapidly decarbonize their operations in the coming decade, a critical point seldom considered in existing projections. In 2020, Amazon, AT&T, Google, Microsoft, Orange and Verizon[33], were just a few of making such pledges. Achieving a conservative 50 percent decarbonization rate for data center and network operations by 2030 globally, based on these commitments, would, in fact, lead to stabilized $CO_2$ emissions at a level below 3 percent of total energy-related emissions, or 0.9$GtCO_2$/y in absolute terms. All of this means that, despite a significant increase in global IT-related electricity demand, the associated environmental impact is likely to be substantially less than feared.

[30] © OECD/IEA (2019), World Energy Outlook 2019

[31] BloombergNEF (2019) New Energy Outlook 2019 (NEO)

[32] Anders Andrae (2020), Hypotheses for Primary Energy Use Electricity Use and $CO_2$ Emissions of Global Computing and its Shares of the Total between 2020 and 2030

[33] Amazon (2020), Amazon announces five new renewable energy projects
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## Digital technologies also favor significant reduction of energy demand across a variety of other sectors

Digital technologies can also help reduce total energy demand. Today's rise in IT services is essentially driven by social networking and video streaming, while that related to IoT enables systemic efficiencies to be leveraged across the energy system. Business-related interactions represent only 20 percent of total internet traffic and, according to Cisco[34], Machine-to-Machine (M2M) connectivity will still represent less than 5 percent of this in 2021. In other words, Business-to-Consumer (B2C) applications represent the largest share of IT services, and the bulk of its growth to 2030, while Business-to-Business (B2B) applications (primarily focusing on dematerialization and efficiency), notably M2M connectivity, represent a minor share.

The potential of energy savings from widespread deployment of M2M has been reviewed by a variety of institutions. Digitally enabled efficiencies were detailed in the International Energy Agency's *Digitalization and Energy*[35] report published in 2017, indicating that up to 25 percent in savings could be expected in freight road transport energy demand. This could be extended to cover private road transport, despite forecasts which continue to vary significantly for this sector. Digitalization could lead to, on average 10 percent savings by 2040 in buildings, thanks to the use of smart controls, taking into account rates of retrofits. Similarly, the integration of digital controls in industry could yield between 6 and 12 percent savings across sectors. In total, efficiency from M2M applications could thus result in potential savings over total energy demand, hence carbon emissions, which dwarf their corresponding additional demand.

Another study from the Global Enabling Sustainability Institution (2020)[36] has carefully reviewed the potential of carbon emissions abatement over 7 countries totaling 21.8Gt$CO_2$e/y of emissions by 2030. Their finding is that between 1 and 2.1Gt$CO_2$e/y could be abated thru the sole deployment of digital technologies. This can be put in perspective to Schneider Electric's overall estimate of a worst-case additional 0.3Gt$CO_2$/y emissions from the sector overall (including B2C applications, and excluding commitments from major IT players).

Such figures can be prey to challenge, and a key uncertainty will obviously be their rate of deployment, but this shows that, while the mitigation of B2C increased energy demand remains a challenge (though probably lower than often anticipated), the deployment of B2B technologies will be key in accelerating the reduction of energy-related $CO_2$ emissions globally, at pace and at cost.

[34] Cisco (2018), Cisco Visual Networking Index (VNI) Complete Forecast Update, 2017–2022

[35] © OECD/IEA (2017), Digitalization and Energy

[36] GeSI (2020), Digital Solutions for Climate Action. Using ICT to raise ambitions on climate actions in low- and middle-income countries.


## Key takeaways

Forecasts on the impact of the IT sector current development over energy demand and carbon emissions vary widely across sources. This is largely due to the lack of standardized measurement framework. In the last decade, several reports have shown as a result widely different outcomes to 2030. The present analysis does not escape the general rule. It nevertheless attempts to provide new insights in light of most recent progress in general understanding over the last 2 years. Notably, the present forecast builds on a detailed bottom-up analysis of IT services demand, and how this growth is mitigated by increased IT and power efficiencies, in our view the only way to properly project the impact of the sector on electricity demand.

As a snapshot of current understanding, this report – as others – would be best understood as a contribution to the global debate, a step forward in generating better global understanding of the true impacts of digitalization over climate mitigation efforts. In the coming years, more efforts will be required to further refine scope discussions, evolving assumptions, while integrating new emerging digital applications in the picture.

This analysis shows that the IT-sector related electricity demand is expected to increase by nearly 50 percent by 2030 (compared to 2020), an increase similar to current available projections of air-conditioning systems in buildings, and twice those of mobility electrification.

Yet, as the electricity system decarbonizes, emissions would not increase by more than 26 percent by that time. Moreover, since large IT players have made firm commitments to decarbonize their operations, while they represent the bulk of the expected increase in electricity demand, the report finds that the increase in emissions from the IT sector could be neutralized by 2030. In fact, the IT sector would still represent less than 3 percent of total energy-related emissions by then.

This analysis therefore puts to rest past concerns of an "out-of-control" rise of emissions stemming from digital technologies. This is not to say that nothing shall be done, on the contrary!

Mitigating the rise of $CO_2$ emissions in the IT sector will require continued efforts in achieving efficiencies on the IT and energy sides, at component and system levels, both for operations as well as for embodied emissions (manufacturing). The rise of edge computing also requires a specific focus as traditionally these systems are expected to be less efficient than hyperscale data centers, from a PUE standpoint.

The IT sector also covers a wide range of services, with B2C applications dominating the landscape. At 5 percent of total, M2M connectivity represents a minor share of global requirements yet growing at rapid pace. This report finds that IoT-enabled technologies however have the potential to significantly tame energy demand and associated carbon emissions in a variety of adjacent sectors, such as buildings, industries and mobility. When reviewing holistically possible decarbonization pathways to 2030 and 2050, their accelerated deployment is therefore a no-brainer and should be prioritized.

# Legal disclaimer

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# Annex – Detailed assumptions and results

## Key assumptions on the IT sector services demand evolution

Scope differences are a key weakness of most existing IT forecasts. It is therefore critical to properly assess the scope considered in this study. This is notably important for devices manufacturing and use, where forecasts tend to vary significantly. Overall, 200 assumptions are keyed in the model.

| Key assumptions on service demand | 2015 | 2020 | 2023 | 2030 |
|---|---|---|---|---|
| Compute workloads (mln) | 200 | 445 | 919 | 3,490 |
| Storage needs (mTB) | 518 | 1,833 | 8,000 | 56,474 |
| - Storage from HDD | 1 | 87% | 80% | 49% |
| - Storage from SDD | 0 | 13% | 20% | 51% |
| DC Infrastructure Global PUE | 2 | 1.5 | 1.4 | 1.3 |
| Global IP traffic (EB/y) | 674 | 2,138 | 5,988 | 30,188 |
| - Share of Mobile vs Fixed IP traffic | 10% | 14% | 23% | 64% |
| - Share of 2G in mobile traffic | | 0% | 0% | 0% |
| - Share of 3G in mobile traffic | 25% | 19% | 11% | 1% |
| - Share of 4G in mobile traffic | 67% | 76% | 86% | 29% |
| - Share of 5G in mobile traffic | 0% | 1% | 4% | 70% |
| Number of destkop + laptops (bn) | 1.2 | 1.2 | 1.2 | 1.1 |
| - share desktops vs laptops | 52% | 43% | 33% | 16% |
| Number of tablets (bn) | 0.5 | 0.8 | 0.9 | 2.0 |
| Number of smartphones (bn) | 3.3 | 5.4 | 6.7 | 9.4 |
| Number of ordinary phones (bn) | 3.7 | 2.0 | 1.5 | 0.7 |
| Number of IoT devices (bn) | 4.9 | 8.3 | 14.5 | 50.6 |
| Number of TVs (bn) | 1.6 | 1.60 | 1.60 | 1.60 |
| Number of TV peripherals (bn) | 2.0 | 1.97 | 1.97 | 1.97 |
| Annual production desktops and monitors (bn) | 0.2 | 0.2 | 0.2 | 0.2 |
| Annual production laptops (bn) | 0.5 | 0.6 | 0.6 | 0.8 |
| Annual production tablets and phablets (bn) | 0.6 | 0.9 | 1.2 | 2.2 |
| Annual production smartphones (bn) | 1.4 | 1.8 | 2.1 | 3.0 |
| Annual production ordinary phones (bn) | 0.5 | 0.5 | 0.4 | 0.4 |
| Annual production modems (bn) | 0.4 | 0.5 | 0.6 | 0.9 |
| Annual production TV (bn) | 0.3 | 0.3 | 0.3 | 0.3 |
| Annual production TV peripherals (bn) | 0.4 | 0.4 | 0.4 | 0.4 |
| Annual production IoT devices (bn) | 0.6 | 1.4 | 3.7 | 5.8 |

Table 1 – Key assumptions on service demand

| Key assumptions on efficiency | 2015 – 2020 period | 2020 – 2030 period |
|---|---|---|
| Annual Improvements in Workloads per Server | 14% | 7% |
| Annual Energy efficiency of Servers | 1% | 1% |
| Annual Improvements in HDD storage capacity | 22% | 10% |
| Annual Energy efficiency of HDD | 5% | 1% |
| Annual Improvements in SDD storage capacity | 43% | 20% |
| Annual Energy efficiency of SDD | 0% | 0% |
| Annual Energy efficiency of Fixed access networks | 16% | 10% |
| Annual Energy efficiency of Mobile access networks | 10% | 5% |
| Annual Energy efficiency of device use: desktops | -2% | -2% |
| Annual Energy efficiency of device use: laptops | 2% | 2% |
| Annual Energy efficiency of device use: TVs | 3% | 3% |
| Annual Energy efficiency of device use: others | 0% | 0% |
| Annual Energy efficiency of manufacturing | 3% | 3% |

Table 2 – Key assumptions on efficiency

## Detailed energy demand from the IT sector

From the set of assumptions considered, electricity demand per key IT service is retrieved, and expressed in TWh per year.

| Electricity demand IT (TWh) | 2015 | 2020 | 2023 | 2030 |
|---|---|---|---|---|
| Compute | 89 | 114 | 150 | 331 |
| Storage | 16 | 18 | 37 | 108 |
| DC infrastructures | 179 | 209 | 242 | 280 |
| Fixed networks | 99 | 160 | 211 | 239 |
| Mobile networks | 84 | 87 | 135 | 409 |
| IT devices use | 195 | 178 | 171 | 144 |
| Network equipment use | 83 | 117 | 143 | 229 |
| IoT devices use | 30 | 70 | 98 | 290 |
| TVs and peripherals use | 498 | 456 | 433 | 387 |
| Device manufacturing | 509 | 527 | 577 | 759 |
| **Total** | **1,782** | **1,935** | **2,198** | **3,177** |

Table 3 – Electricity demand growth of the IT sector

## Share of global electricity demand

Global electricity generation is well estimated by key agencies (in this case BloombergNEF forecasts are used[37]). To retrieve electricity demand, we assume 8.3% losses[38] in T&D infrastructures globally. This enables to compute the share of IT sector demand over final electricity demand.

| Global Electricity generation | 2015 | 2020 | 2023 | 2030 |
|---|---|---|---|---|
| Electricity generation (TWh) | 21,229 | 24,644 | 26,382 | 30,718 |
| Share of IT sector vs total electricity demand | 9.3% | 8.7% | 9.3% | 11.5% |

Table 4 – Share of the IT sector in total electricity demand

## Carbon emissions from the IT sector

The table below is a simple calculation of associated carbon emissions based on projected global electricity generation carbon intensities (from BloombergNEF[39]).

We also add an additional 2030 projection, accounting for a global reduction of carbon intensities of data centers and telecommunication industries of 50% by 2030. Emissions to 2030 range between 0.899Gt$CO_2$/y and 1.2Gt$CO_2$/y, compared to a 2020 estimate of 0.955Gt$CO_2$/y.

| Carbon emissions (Mt$CO_2$/y) | 2015 | 2020 | 2023 | 2030 | 2030 decarbonized |
|---|---|---|---|---|---|
| Global Electricity $CO_2$ intensity (g$CO_2$/kWh) | 548 | 494 | 458 | 378 | 378 |
| - Compute | 49 | 56 | 69 | 125 | 63 |
| - Storage | 9 | 9 | 17 | 41 | 20 |
| - DC infrastructures | 98 | 103 | 111 | 106 | 53 |
| - Fixed networks | 54 | 79 | 97 | 90 | 45 |
| - Mobile networks | 46 | 43 | 62 | 155 | 77 |
| - IT devices use | 107 | 88 | 78 | 54 | 54 |
| - Network equipment use | 46 | 58 | 65 | 87 | 43 |
| - IoT devices use | 16 | 35 | 45 | 110 | 110 |
| - TVs and peripherals use | 272 | 225 | 198 | 146 | 146 |
| - Device manufacturing | 279 | 260 | 264 | 287 | 287 |
| Total | 976 | 955 | 1,006 | 1,201 | 899 |
| Share of global energy-related emissions | 3.1% | 2.8% | 3.0% | 3.4% | 2.6% |

Table 5 – Carbon emissions from the IT sector

[37] BloombergNEF (2019), New Energy Outlook

[38] Jacobson (2019), Reducing T&D Losses Allows Faster Retirement of Fossil. Stanford University

[39] BloombergNEF (2019), New Energy Outlook

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## About the author

**Vincent Petit**
Strategy Prospective and External Affairs, head of the Sustainability Research Institute, Schneider Electric

**Steven Carlini**
Vice President Innovation and Data Center, Schneider Electric

**Victor Avelar**
Director, Senior Research Analyst, Data Center Research Center

**Schneider Electric**

998-21202519